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## THE DEBT OF AMERICAN MICROSCOPY TO SPENCER AND TOLLES

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PAST PRESIDENT OF THE A. M. S.

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WITH FIVE PLATES

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There recently died in Buffalo the last of a distinguished trio of lensmakers who, by their ingenuity and inventiveness, added a brilliant chapter to the history of American genius.

Charles A. Spencer, Robert B. Tolles, and Herbert R. Spencer were artists rather than artisans in their chosen field of applied optics, and they left their impress deeply engraved upon the history of their time.

Although their obituaries have appeared in the *Transactions*<sup>1</sup> of this Society at the proper time, nevertheless it will not be uninteresting or tedious to review their work or recall their efforts in behalf of improved scientific apparatus. Records show that up to 1840 little if any use was made of the compound microscope in America, and no instrument maker had appeared who could supply an instrument of any kind. Thus it was when in this year the United States exploring expedition to the South Seas under Commodore Wilkes was fitting out, no instrument could be furnished the expedition by any of the makers of scientific or philosophical instruments in America. In this dilemma a private individual was applied to, and an instrument was finally loaned from Dr. Paul Goddard of Philadelphia. It was a French microscope of inferior make, but the best obtainable at that time. Since then the instrument has come into general use, and in certain departments of the manufacture of microscopes this country has become preeminent. Scarcely had the English microscope makers published those inventions and discoveries which rendered achromatic microscopes really possible, and ele-

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<sup>1</sup> Memoir of Charles A. Spencer by Hamilton L. Smith, LL.D. *Transactions American Society of Microscopists*, 1882, p. 49.

Memoir of Robert B. Tolles by George E. Blackham, M.D. *Transactions American Society of Microscopists*, 1884, p. 41.

vated the instrument from the position of a mere scientific plaything to that of an instrument calculated for the most accurate investigations, before the elder Spencer succeeded in producing lenses which at once took a front rank among the art productions of the world. To-day we stop in the mad whirl of our busy lives to pay homage to Charles A. Spencer and his two famous pupils, Robert B. Tolles and Herbert R. Spencer.

At the Seventh Annual Meeting of this Society, held at Rochester, N. Y., August 19 to 22, 1884, a memoir of Robert B. Tolles, but recently deceased, was read by Dr. George E. Blackham, of Dunkirk, N. Y. In the remarks following by different members of the Society, a resolution was offered by W. H. Breasley, of Detroit, that W. A. Rogers be requested to prepare a subscription paper and to receive subscriptions for a monument to Robert B. Tolles. As a substitute motion Professor T. J. Burrill, of Champaign, Ill., offered the following, which was seconded and adopted:

*Resolved*, That W. A. Rogers, H. J. Detmers, and George E. Blackham be made a committee to report upon proper action, on the part of the Society, in memory of Robert B. Tolles.

Mr. Breasley then offered the following resolution:

*Resolved*, That the same committee be asked to consider and report upon a suitable memorial for Charles A. Spencer,

which was also seconded and unanimously carried.

Thus the ground was broken for the foundation of a monument to Spencer and Tolles, which was to be as durable and ineffaceable as a granite shaft, but, unlike the stone, it was to shed warmth and awaken a quickening in the minds of all those fortunate enough to come within its shadows.

At the next meeting of the Society, held at Cleveland, O., August 18 to 21, 1885, Dr. George E. Fell, of Buffalo, N. Y., reported the condition of the Spencer-Tolles Memorial Fund as follows:

*To the Officers and Members of the American Society of Microscopists:*

In accordance with the resolutions on a Spencer and Tolles Memorial Fund, the following report is presented: The first cash subscription to this fund was made by the Royal Microscopical Society, December 17, 1884. Since that time the subscriptions have come in so slowly that this report will present but a meager list of subscribers, and, in view of the unanimous adoption of the resolution establishing the fund, not nearly so large a list as should have been expected. Prof. Wm. A. Rogers, with his characteristic action in furthering any

of the projects of the Society, has offered to subscribe \$25 and guarantees \$15 additional, contingent, however, upon a concerted action of the Society towards the increase of the fund. He suggests that the income of the fund be awarded in prizes for specific original research. The subscriptions to the fund are given below:

Royal Microscopical Society.....	\$25 20
J. D. Cox.....	5 00
D. S. Kellicott.....	5 00
George E. Fell.....	5 00
John Kruttschnitt.....	5 00
F. S. Newcomer.....	5 00
Chas. Shepard.....	5 00
E. H. Griffith.....	5 00
Total.....	<hr/> \$60 20

Respectfully submitted,

GEORGE E. FELL,

*Treasurer and Custodian.*

The fund grew slowly; custodian gave way to custodian, each doing his best to swell the amount as much as possible. As was the case in our Civil War, there were many generals, but only *one* general, so with the Spencer-Tolles Fund, there were many custodians but only *one* custodian, and to-day the American Microscopical Society acknowledges its debt of gratitude to our present custodian, and the many friends of Spencer and Tolles, in and out of our Society, extend their hearty congratulations to our genial, energetic, and aggressive friend, Magnus Pflaum, Esq., of Pittsburg, who has the distinction, aided by our worthy Secretary, of having their long years of patient labor brought to a triumphant close. It might be pertinent to suggest at this time that the Society take some official action to connect the name of Herbert R. Spencer to those of Charles A. Spencer and Robert B. Tolles, so that this fund may stand as a monument to the genius of the three men instead of the two older, as it *now* officially stands.

Many of the recent advances in medicine have been due to the improved microscope and the application of certain compound stains to certain tissues, whereby a part of a tissue will be stained one color and another part a contrasting color. These parts may be so infinitesimal, however, that the very best and improved microscopes are necessary to detect the differences; hence, to the stain and microscope we are indebted for the wonderful discoveries made in

science dating from the time that Robert Koch made his famous discovery of the bacillus of tuberculosis in 1882.

The microscope is composed of a manifold variety of parts made for the sole purpose of giving the greatest scope and efficiency to the lenses which constitute the vital part of every optical instrument. Scientists, therefore, divide the microscope into stand and lenses, the former comprising the mechanical or brass parts, the latter the lenses or glass parts.

A good microscope should have a stand fitted with all the mechanical niceties necessary to make the lenses available for practical scientific work, and, secondly, lenses which will interpret correctly and accurately the enlarged image of the object to be studied. Lenses which will distort or nullify the enlarged image are said to be uncorrected for spherical and chromatic aberrations, and these defects are serious ones in a good working lens. Hence, no matter how perfect and complete the mechanism of the microscope stand, if the lenses are not perfect or nearly so, careful, accurate work can not be accomplished. The lenses in a microscope are classified into those forming the objective or object glass placed just above the object to be magnified, and the ocular or eye-piece placed at the other end of the tube near the eye of the observer. The special purpose of the objective is to form an enlarged inverted real image of the object, and that of the ocular is to magnify the image formed by the objective. Thus it will be apparent that, no matter how good the stand and perfect the ocular or eye-piece, if the objective or field lens is imperfect the efficiency of the whole instrument is impaired.

The qualities of a good objective are manifold. It must of course possess magnifying powers; it must magnify an object without distorting it or surrounding it with a color zone; it must magnify the object equally, circumferentially as well as centrally, i. e., there must be flatness of field; it must permit the passage of a large amount of light so that the image of the object shall be well illuminated, but, more than all else, the objective should have great resolving power, that is, it should be able to define or make clear the minute details of an object. The prime requisite of a lens is not that it shall magnify so many hundred or thousand diameters, but that it shall have great resolving power or resolution. To illustrate what is meant by resolving power, take the ordinary opera glass, which simply gives an enlarged picture of the actress on the stage

with a general superficial outline of face, form, and dress; if the lenses had good resolution, the make-up of the face, the quality and texture of the dress, the genuineness or imitability of the jewels and the like would be revealed. Hence opera glasses should have low resolving power lenses, so as to blend the component parts into a harmonious whole, and not disintegrate the various elements into an incongruous mass showing up the component parts by contrast.

It was this superior quality of a lens that Charles A. Spencer, Robert B. Tolles, and Herbert R. Spencer sought after so assiduously and succeeded so admirably in attaining that made them the peers of greatest among lensmakers the world over. They were the pioneers, the pathfinders, among lensmakers, and they succeeded in making objectives of such superior quality and such high merit that their work had to be well-nigh forgotten and then rediscovered, or, better, resurrected by some foreign genius before the world realized what the Spencers and Tolles had accomplished in the '40s and '50s. So true is this that hardly had the din of applause died out over the discovery of the apochromatic lens by a well-known German scientist than Herbert R. Spencer showed me a lens constructed on the same principle and of the same substance, fluorspar, that his father made in the early '50s and had abandoned because of the great deteriorating quality of the fluorspar. The same fault is again being found with the resurrected lenses.

Charles A. Spencer was born in the town of Lennox, N. Y., in 1813. He descended from a well-known and highly respected family, his father being Gen. Ichabod Spencer; an uncle was the late Judge Joshua A. Spencer, of Utica, and another uncle was Dr. Thomas Spencer, of Geneva, professor in the old Geneva Medical College. He was educated at the Cazenovia Academy, then entered Hobart College, where he remained less than a year, and soon after went to Hamilton College, Clinton, N. Y. Of his early boyhood, Dr. Hamilton L. Smith, of Geneva, N. Y., says in a memoir published in the *American Microscopical Society's Transactions* for 1882 that "he seems to have had an all-controlling idea, a self-consciousness, which seemed but conceit to those who did not understand him or realize how much there really was in him, of his ability to produce better optical work than the world had yet seen. There is in existence a portrait of him taken when he was but sixteen years

old, and which must have been a very truthful likeness, for it shows clearly the character of the future man. He is looking straight forward with fearless eye and already reading on the scroll of fame the name of Charles A. Spencer." (See Plate V.)

Spencer was induced, while still a lad, by the perusal of the article on "Optics" in the Edinburgh Encyclopedia, to construct a compound microscope. His first attempt at making a lens was when he had scarcely attained his twelfth birthday, and although crude and unfinished it spoke to him of the vast possibilities which lay before him in the field of applied optics. Genius that he was, he discovered its errors and imperfections, and, *the master* within him asserting itself, he set out upon his life's journey of correcting these and improving each subsequent endeavor. He then attempted to combine his lenses and succeeded in making several compound microscopes and a refracting microscope upon the original plan of Professor Amici. He also constructed several Gregorian and Newtonian telescopes with specula of six and eight inches diameter, some of which were quite successful. Spencer was greatly handicapped during these early years by a combination of circumstances, one of which, the most serious to him, happily no longer confronts the investigator of to-day.

The loss of "interchange of ideas" was a drawback to this young scout appreciated only by those entering new fields of conquest. Working by himself, without guide or precedent, it was a most difficult task to improve only along certain lines which appealed most strongly to him. It was not until the publication of the *Penny Magazine* and the Library of Universal Knowledge, however, that he became aware of the improvements which had been made in Paris and London in the achromatic microscope. The results obtained by Goring and Pritchard, in both the achromatic and reflecting microscopes excited his attention especially. The discovery by the former of the effects of angle of aperture was a powerful inducement for young Spencer to perfect himself more thoroughly in this branch of optical science. About this time he also learned of the successful researches of Guinaud, Fraunhofer, and Faraday in the manufacture of optical glass. By laborious and protracted experiments, frequently working over the furnace for eighteen consecutive hours, he succeeded in improving the homogeneity and other qualities of the glass considerably, enabling him thereby

to make an evident advance upon his previous efforts in constructing lenses.

About 1838 Charles A. Spencer announced himself as a manufacturer of telescopes and microscopes and with his workshop located at Canastota, N. Y. In spite of business reversals he still continued to devote himself to the perfection of the achromatic telescope and microscope. Ten years later lenses were made at the little shop in Canastota which mystified English and French microscopists, chiefly because of their great resolving power. The charge was made against Mr. Spencer by the English makers that he must have some mode of working glass as yet unknown to other opticians. While this was partly true, yet his chief success was from his tact in figuring the lenses so as to balance the aberrations, a process so delicate that it would have availed no one not possessed of the same skill to copy curves, even if this could be done, and with the same material.

In June, 1850, Mr. Spencer produced a  $\frac{1}{12}$ -inch objective, having the then marvelous aperture of  $174\frac{1}{2}^\circ$  as measured by the old sector method. This innovation aroused the wrath of his competitors, who declared that the limit of usefulness could not exceed  $135^\circ$ . These high-angled objectives were not only useful but were possessed of such great and wonderfully accurate defining power that their fortunate possessors considered them as superior to any lenses ever made. Spencer's idea was to combine large angular aperture with definition, and in this respect he scored a signal success over his competitors who were only able to increase the angle at the expense of the definition.

In other fields Mr. Spencer was also active, especially in the manufacture of telescopes. In 1865 he completed a large equatorial for Hamilton College having an object glass of  $13\frac{1}{2}$  inches diameter and a focal length of 16 feet, being the largest telescope then in this country.

In the fall of 1873 a disastrous fire broke out in Canastota, which destroyed Mr. Spencer's shop, nearly all the tools and machinery, the accumulation of many years of toil and skill, and a large amount of finished and unfinished work. Crippled, but not disheartened, Mr. Spencer and his sons removed to Geneva, N. Y., in 1875, and in a barn for a workshop started anew to electrify the world with their matchless lenses. Some of these were in possession of Pro-



fessor Barnard of Columbia College, one of the United States commissioners to the Paris Exposition of 1878; and so convinced was he of their excellence that he entered them without the knowledge of the Spencers. To the surprise and amazement of European opticians and to the gratification of the Spencers and their many friends and admirers, they were awarded a magnificent large gold medal for excellence and superiority.

In 1880 Herbert R. Spencer began business for himself, while the father remained in the old shop, loath to sever connections with the work he so dearly loved and which he so richly adorned. He died in Geneva, N. Y., on September 28, 1881. The American Society of Microscopists made him one of its first honorary members on August 10, 1881. (See Plate VI.)

The second member of the illustrious trio was Robert B. Tolles, an apt student of an apt master. "The story of his life is a simple and touching narrative of the struggle of genius with poverty and ill-health; of steady persistence in the face of apparently insurmountable obstacles and of final and triumphant success." Robert B. Tolles was born in Winchester, Conn., and passed his boyhood struggling to gain a meager education, while at the same time helping to support his parents, who were very poor. His father was an inventor, but from lack of funds was unable to develop any of his ideas. In 1843, after the death of his mother, young Tolles went to visit an uncle residing near Rochester, and on his way back happened, by chance, to stop at Canastota, N. Y., where he accidentally visited the workshop of Charles A. Spencer. Looking around him he recognized at once the opportunity, "knocking unbidden once at every gate," and said, "here is the place and the work for me."

He entered the service of Mr. Spencer as apprentice and remained with him for fifteen years, imbibing the spirit of the master and adding to the fame of the little backwoods shop by numerous inventions, a trait, no doubt, inherited from his father. Tolles's object in life was the improvement of the microscope, and he was well qualified, by his "great theoretical and practical knowledge of the science of optics, united with mechanical and inventive genius and marvelous skill of eye and hand." Among some of the things accomplished was a cover correction for objectives; a stereoscopic binocular eye-piece; mechanical stage; a solid eye-piece; objectives with two fronts, one immersion, the other dry; and in 1873 he suc-

ceeded in making an immersion or one-tenth objective with an aperture greater than that corresponding to infinitely near to 180 degrees in air. It was a three-system lens and had an aperture of more than 110° in balsam or 1.25 N. A.

On this event, Dr. George E. Blackham, of Dunkirk, N. Y., in his memoir of Tolles in the *Transactions of the American Society of Microscopists*, in 1884, says: "The importance of this bold step and its influence upon the progress of microscopy can scarcely be estimated at this time, but it is certain that it was the cause of a revolution of opinion and practice among users and makers of microscopes all over the world."

In 1867 he removed to Boston and affiliated with the Boston Optical Works. The last ten years of his life were years of suffering and hardship, working at his bench when he should have been in bed, denying himself all the luxuries and many of the comforts of life. During his last illness he had the microscope brought to his bedside and there on his deathbed examined and tested the lenses. Only a few minutes before his death he was occupied in correcting the degrees of aperture of an imaginary lens, and when he reached 150 degrees he stopped, turned his head, and said faintly, "Good-bye," on November 17, 1883. Robert B. Tolles was elected an honorary member of the American Society of Microscopists on August 10, 1883. (See Plate VII.)

The third member of the illustrious group was, like his predecessors, a genius, who ranked high with his father and friend in this country and with Amici, Abbe, Powell, Chevalier, Oberhauser, Ploessel, Hartnack, and Ross in Europe. Herbert R. Spencer was born at Canastota, N. Y., on November 1, 1849, and removed to Geneva with his father in 1875. At an early age he became imbued with the atmosphere of genius which surrounded him, and while yet a mere lad began to make lenses on a lathe of his own construction, equaled in those days only by those of his father and co-worker Tolles. (Pl. IX.) A more suitable workshop and better tutelage than that offered at Canastota could not have been found for young Spencer. To be in daily touch with a mind like his father's and rubbing against an all-around inventive genius like Tolles sharpened his imaginative and perceptive faculties so that as understudy he was prepared to step into their places at any time, without the scientific world knowing or realizing that a succession had taken place. And so it

happened that in 1880 Herbert R. Spencer carried on the business of making microscopes, telescopes, and other optical instruments without the world knowing that the father was practically through with his life's work. The Spencer lenses seemed to be just as perfect and as much sought after in the '80s and '90s, under the son, as they were in the '50s, '60s, and '70s, under the father and Tolles. In 1889 he removed to Cleveland and organized the H. R. Spencer Optical Company. In 1891 Mr. Spencer decided to remove to Buffalo, and since then the famous Spencer lenses have found their home in this city. In 1895 the Spencer Lens Company was organized in Buffalo, many of the stockholders being practical microscopists. (See Plate VIII.)

A peculiar trait of the Spencers was the confidence in their ability to improve on their lenses. No matter how good the resolution, how clear the definition, they always insisted that it was not their best. As Mr. Howland has said of Spencer's work,<sup>2</sup> "He was ambitious and critical of it; there was always in his own vision a better that mocked his best, and he was never satisfied until that better was secured and a better still beckoned him forward."

Just as prosperity began to warm the Spencer heart and home the stress and strain of years of toil and anxiety began to tell, and in the fall of 1899 Mr. Spencer was obliged to discontinue his work. Foreseeing the inevitable, he had trained some of his assistants to do the testing and setting of lenses under his personal supervision, so that when the Spencers should cease to exist as opticians, the Spencer idea embodied in the Spencer lens would still live on. The end came on February 7, 1900, and was a severe blow to his many friends and acquaintances, many of whom did not even know of his illness. Mr. Spencer was for many years a member of the American Microscopical Society and a fellow of the Royal Microscopical Society of London.

These three men, giants in their line, had many traits in common, some to be commended, others, especially in this age of materialism, to be condoned. Their innate confidence in their powers, so characteristic of the elder Spencer and not less marked in Tolles and Herbert Spencer, strikes the casual observer as most uncommon; their ability or conceptive faculties, linked with an acute

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<sup>2</sup> Memoir of Herbert R. Spencer, by Henry R. Howland. *Trans. Am. Micros. Soc.*, 1899, p. 252.

comprehension of the laws of optics, was a peculiarity to all three, and stood them in great service. Their retiring, unassuming dispositions, their habitual shyness and professed abhorrence of notoriety were factors inimical to their welfare and impeded their commercial progress. Financially they were not successful, but inasmuch as they resolved to produce lenses of quality and not lenses in quantity they left a private fortune to each individual possessor of their beautiful handiwork. The writer believes with Hamilton L. Smith, in his memoir already referred to, that "when the name of many a successful man, as the world counts success, shall have been forgotten, and the marble on which alone it is recorded shall have crumbled away, that of Spencer will live; nor will it be forgotten until the human eye no longer needs a microscope, but shall see clearly the now hidden things of God."

**EXPLANATION OF PLATES****Plate V**

CHARLES A. SPENCER (when 16 years old)

From a portrait painted by his brother Frederick, when 19 years old. The original painting was kindly donated to the Buffalo Academy of Science by Mrs. H. R. Spencer.

**Plate VI**

CHARLES A. SPENCER

**Plate VII**

ROBERT B. TOLLES

**Plate VIII**

HERBERT R. SPENCER

Taken a short time before death.

**Plate IX**

Lathe made by Herbert R. Spencer when he was 13 years old and on which he made his first objective. The lathe was kindly donated to the writer by Mrs. H. R. Spencer.

**PLATE V**



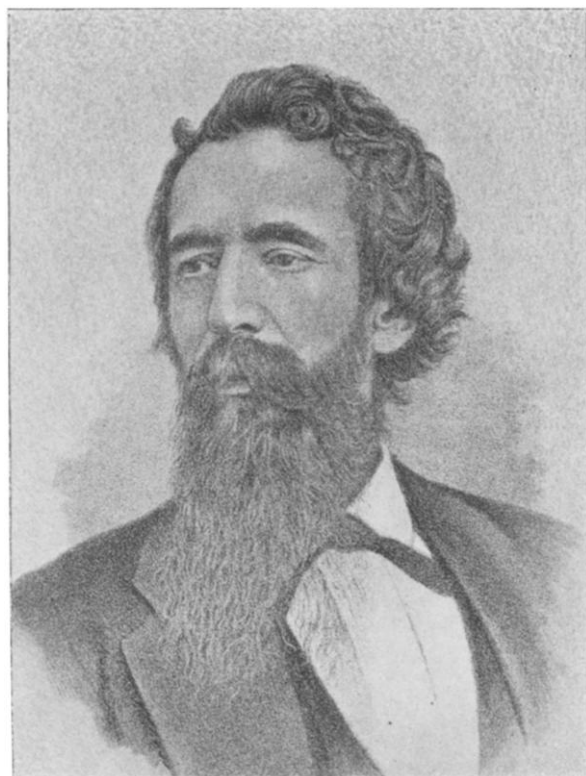
**CHARLES A. SPENCER**

**PLATE VI**



**CHARLES A. SPENCER**

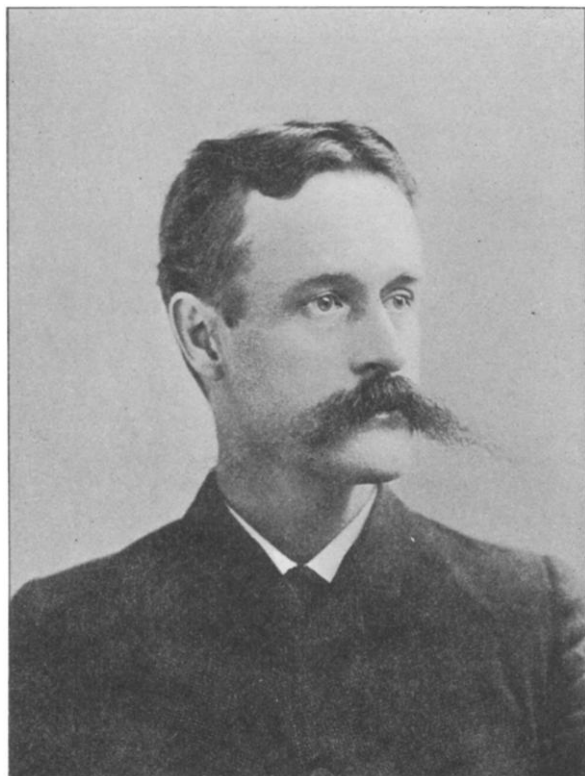
**PLATE VII**



**ROBERT B. TOLLES**



**PLATE VIII**



**HERBERT R. SPENCER**

PLATE IX

